Potential Impact of Aircraft Technology Advances on Future CO_2 and NO_X Emissions

NASA Environmental Compatibility Research Workshop II
May 19, 1998

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Impact of Technology on Future Emissions
Presentation Outline

PURPOSE OF STUDY

HISTORICAL DEMAND AND EMISSION TRENDS

AVIATION GROWTH SCENARIOS

FUTURE TECHNOLOGY SCENARIOS
- International Coordinating Council of Aerospace Industries Associations
- NASA
- Technology Scenario Comparison

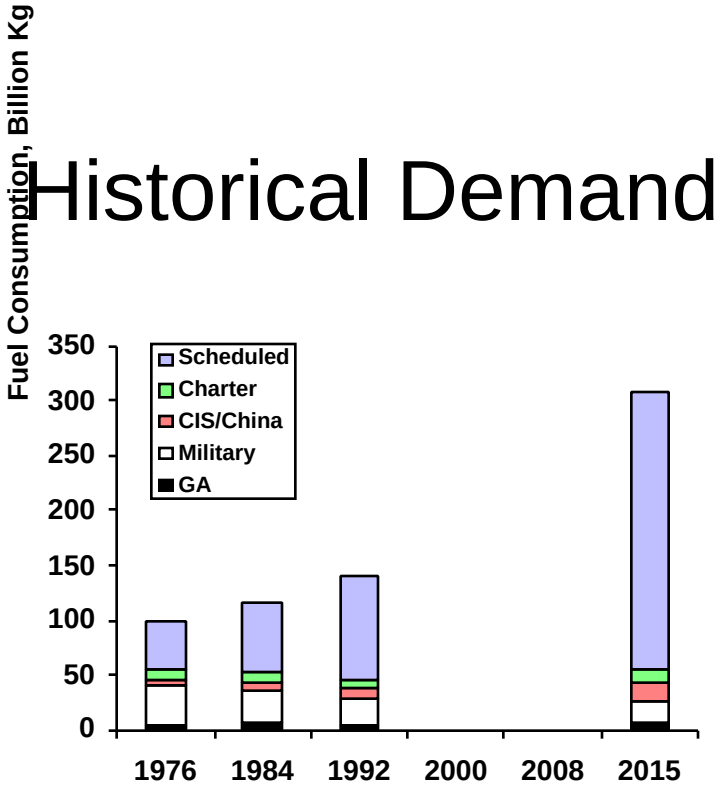
IMPACT OF TECHNOLOGY ON FUTURE EMISSIONS
- International Civil Aviation Organization (ICAO) Projections with ICCAIA Scenarios
- NASA Projections

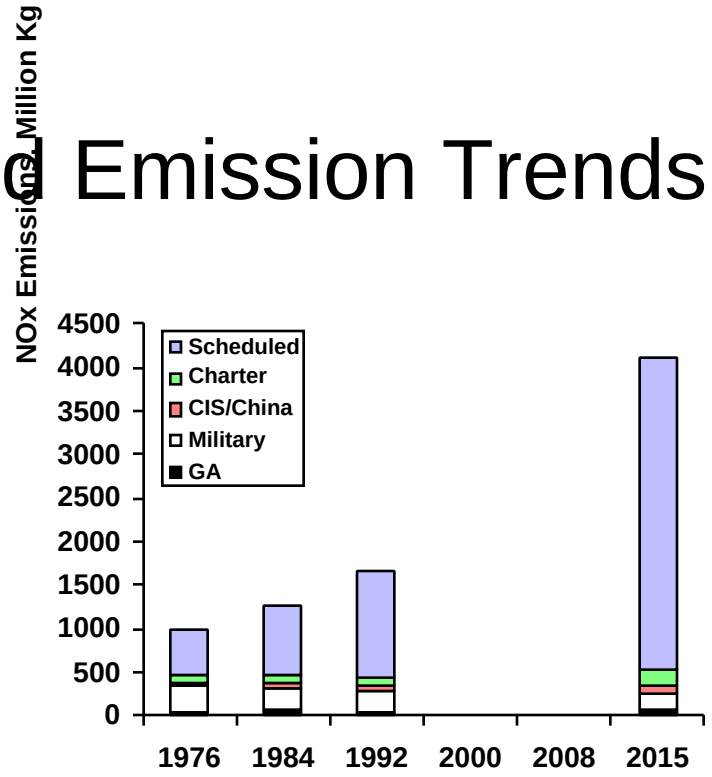
SUMMARY & CONCLUSIONS

Impact of Technology on Future Emissions
Purpose of Study

- The purpose of this study was to assess the *POTENTIAL* impact of technology advances on future emissions.
- The NASA technologies used to project the future are at various levels of maturity. Some may be deemed impractical after additional research, or the expected benefits may diminish as further data is obtained.
- Costs associated with development and implementation of technologies have not yet been examined but these costs as well as operating costs will be required to determine effective technologies for emission reduction.
- For the NASA technologies to be viable they must be compatible with the other NASA “3 Pillar” goals, including the affordability of air travel goal.

Historical Demand and Emission Trends





- Through the Atmospheric Effects of Aviation Project (AEAP) NASA has funded several inventories of worldwide fuel consumption, NO_X, CO, HC emissions
- Inventory years include 1976, 1984, 1992 and a 2015 forecast

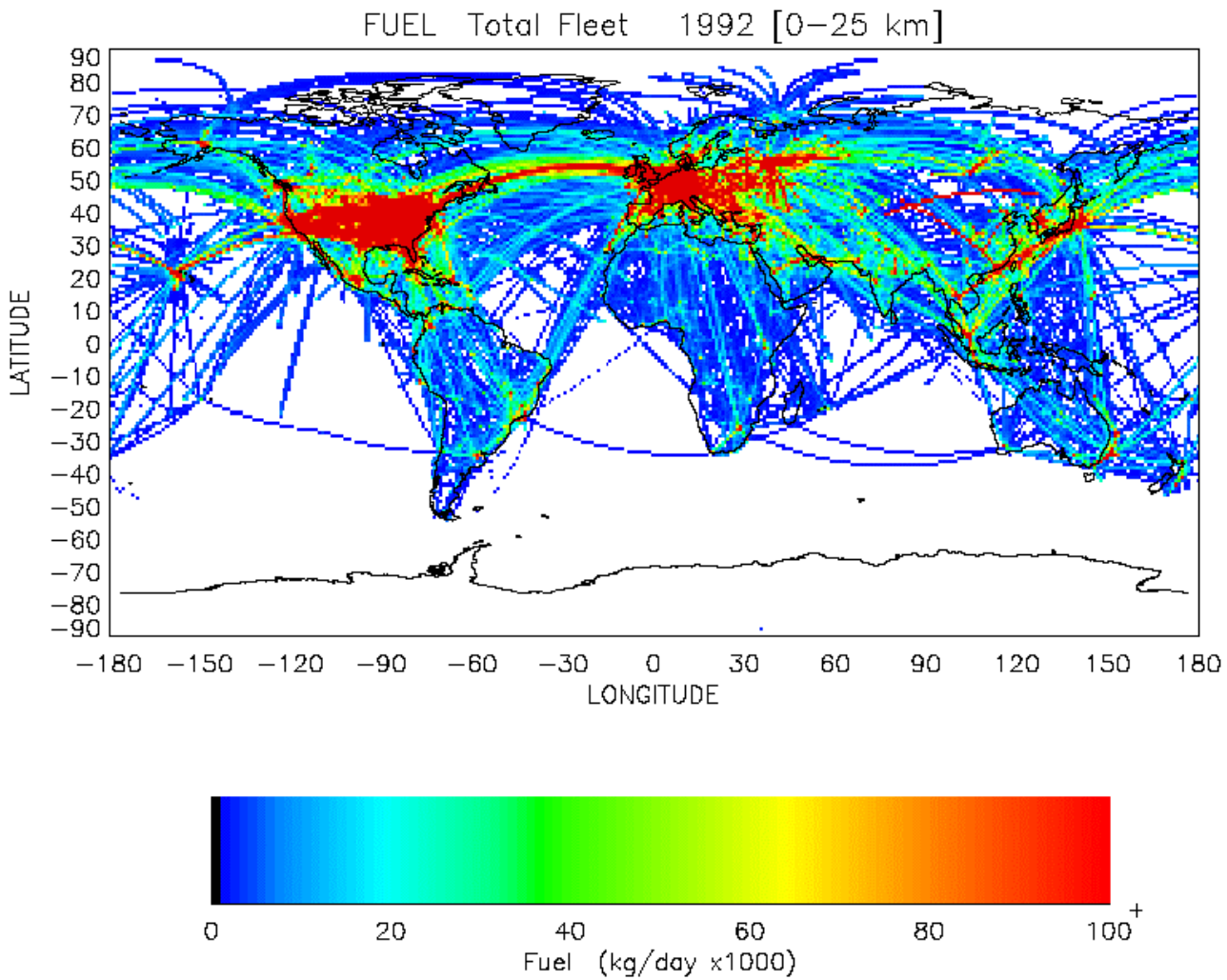
1976-1992 Average Annual Growth Rates ("Scheduled" Traffic)

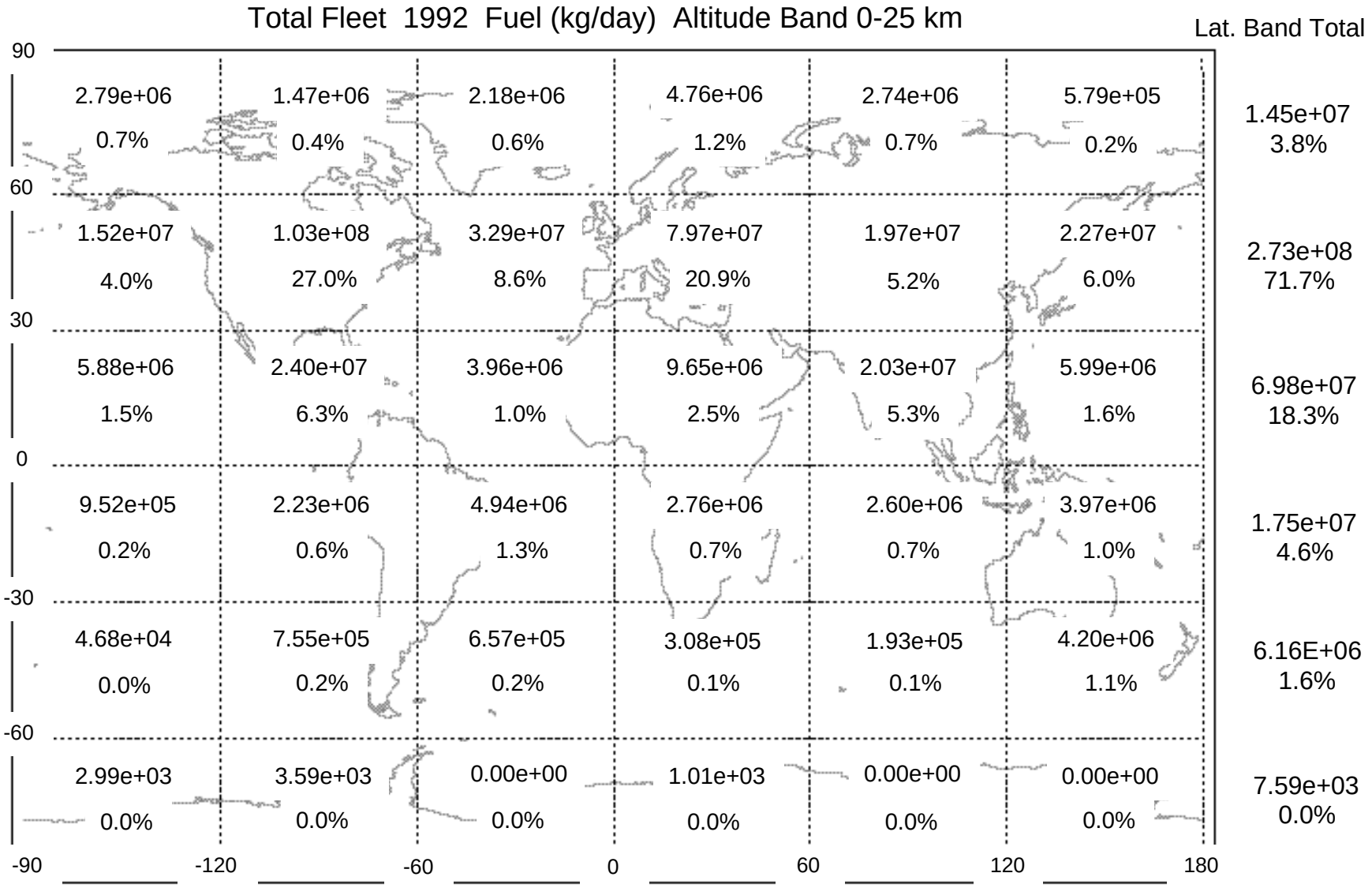
revenue passenger miles: **5.6%**

fuel consumption: **4.6%**

NO_X emissions: **5.8%**

average EI(NO_X): **1%**


FUEL Total Fleet 1992 [0–25 km]
LATITUDE
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−180 −150 −120 −90 −60 −30 0 30 60 90 120 150 180
LONGITUDE
0 20 40 60 80 100+
Fuel (kg/day x1000)


Total Fleet 1992 Fuel (kg/day) Altitude Band 0-25 km
Lat. Band Total
90
60
30
0
-30
-60
-90
-120
-60
0
60
120
180
2.79e+06
0.7%
1.47e+06
0.4%
2.18e+06
0.6%
4.76e+06
1.2%
2.74e+06
0.7%
5.79e+05
0.2%
1.45e+07
3.8%
1.52e+07
4.0%
1.03e+08
27.0%
3.29e+07
8.6%
7.97e+07
20.9%
1.97e+07
5.2%
2.27e+07
6.0%
2.73e+08
71.7%
5.88e+06
1.5%
2.40e+07
6.3%
3.96e+06
1.0%
9.65e+06
2.5%
2.03e+07
5.3%
5.99e+06
1.6%
6.98e+07
18.3%
9.52e+05
0.2%
2.23e+06
0.6%
4.94e+06
1.3%
2.76e+06
0.7%
2.60e+06
0.7%
3.97e+06
1.0%
1.75e+07
4.6%
4.68e+04
0.0%
7.55e+05
0.2%
6.57e+05
0.2%
3.08e+05
0.1%
1.93e+05
0.1%
4.20e+06
1.1%
6.16E+06
1.6%
2.99e+03
0.0%
3.59e+03
0.0%
0.00e+00
0.0%
1.01e+03
0.0%
0.00e+00
0.0%
0.00e+00
0.0%
7.59e+03
0.0%

Aviation Growth Scenarios

- Scenarios for future, worldwide scheduled traffic demand have been developed by the Forecasting and Economic Support Group (FESG) of ICAO
  - Based on socio-economic scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) for projection of the future atmosphere
  - FESG model assumes aviation growth rate will level off at global gross domestic product growth rate as market reaches maturity
  - Growth assumes sufficient infrastructure and capacity to handle demand and continued availability of fuel at moderate prices

IPCC Scenario IS92c => average growth rate of 2.0% from 1995 to 2050

IPCC Scenario IS92a => average growth rate of 3.1% from 1995 to 2050

IPCC Scenario IS92e => average growth rate of 3.9% from 1995 to 2050

Future Technology Scenarios

International Coordinating Council of Aerospace Industries Associations (ICCAIA)

- Projections of fuel efficiency and NO_X technology levels out to 2050
- Two scenarios: one with focus on fuel burn (CO_2) and NO_X reduction, the other aggressive NO_X reduction at the possible expense of fuel efficiency

NASA Scenario - Possible Benefits of NASA Technology Development

- Technologies developed in NASA Advanced Subsonic Technology (AST) program assumed to have initial entry into service of 2007 - 8 years assumed for benefits to be fully realized on all new aircraft
- Technologies currently in NASA base program assumed to have continued development, initial entry into service of 2017 - 6 years assumed for benefits to be fully realized on all new aircraft
- Full projected/goal benefits of program elements applied to all classes, “rolled-up” to aircraft level benefits
- Benefits applied to “conventional” aircraft - no benefit from advanced concepts included (e.g. Blended Wing Body, Box Wing)
- Scenario optimistic due to assumption that all programs 100% successful and technologies economically viable

Future Technology Scenarios

Technology Scenario Comparison

	YEAR	FUEL	LTO NO_x
ICCAIA Scenario 1	By 2050	40-50% increase in (new) production avg. fuel efficiency	maintain fleet avg. 10-30% below CAEP2
ICCAIA Scenario 2	By 2050	30-40% increase in (new) production avg. fuel efficiency	production avg. 50-70% below CAEP2 (30-50% below by 2020)
NASA Scenario *Possible Benefits of NASA Tech.* (calculated effect)	AST By 2015 (Initial EIS 2007)	25% increase in production avg. fuel efficiency	production avg. ~60% below CAEP2
	AST+Base BY 2023 (Initial EIS 2017)	50% increase in production avg. fuel efficiency	production avg. ~70% below CAEP2

Impact of Technology on Future Emissions

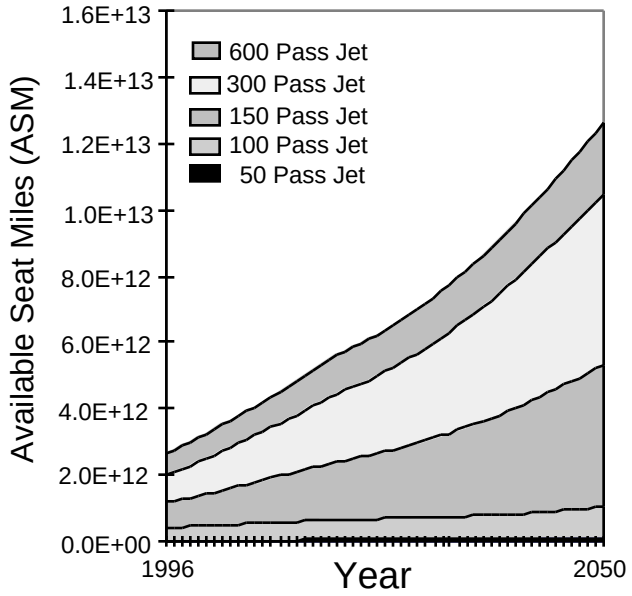
ICAO Forecasting and Economic Support Group (FESG)

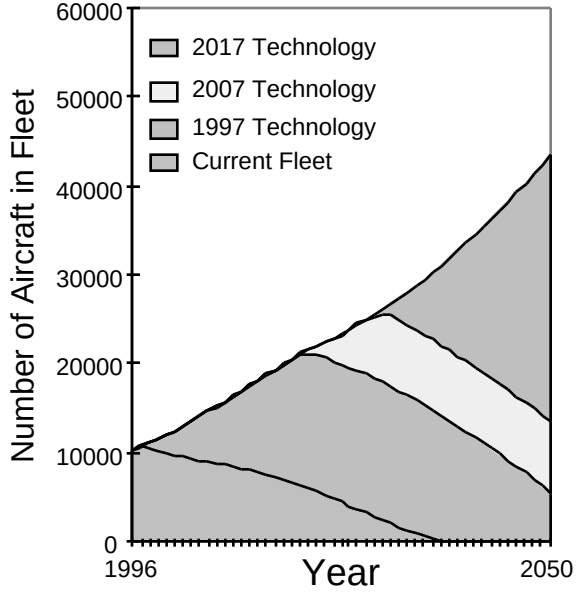
- For scheduled traffic FESG converted ICCAIA technology scenarios to fleet average fuel efficiency and fleet average EI(NO_X) for 2050
- For military sector and general aviation, technology assumed same as for 2015 inventory with exception of improvement in fuel efficiency for GA jets and turboprops
- For charter and CIS/China sectors, technology assumed same as for scheduled aircraft fleet
- Projected average fuel efficiency and average EI(NO_X) were combined with demand scenarios to determine aviation fuel consumption and NO_X emissions for 2050

Impact of Technology on Future Emissions

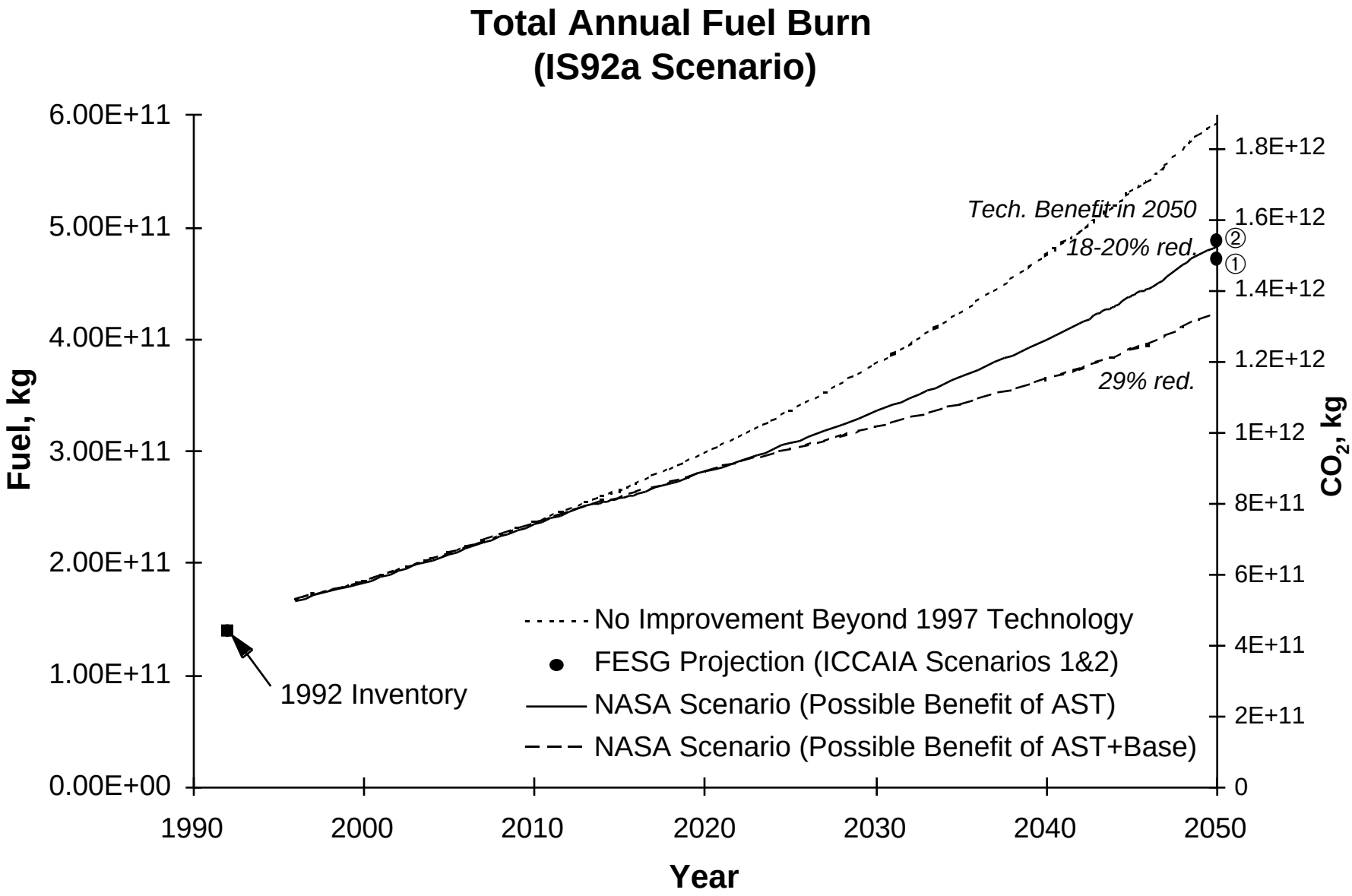
NASA Scenario - Possible Benefits of NASA Technology Development

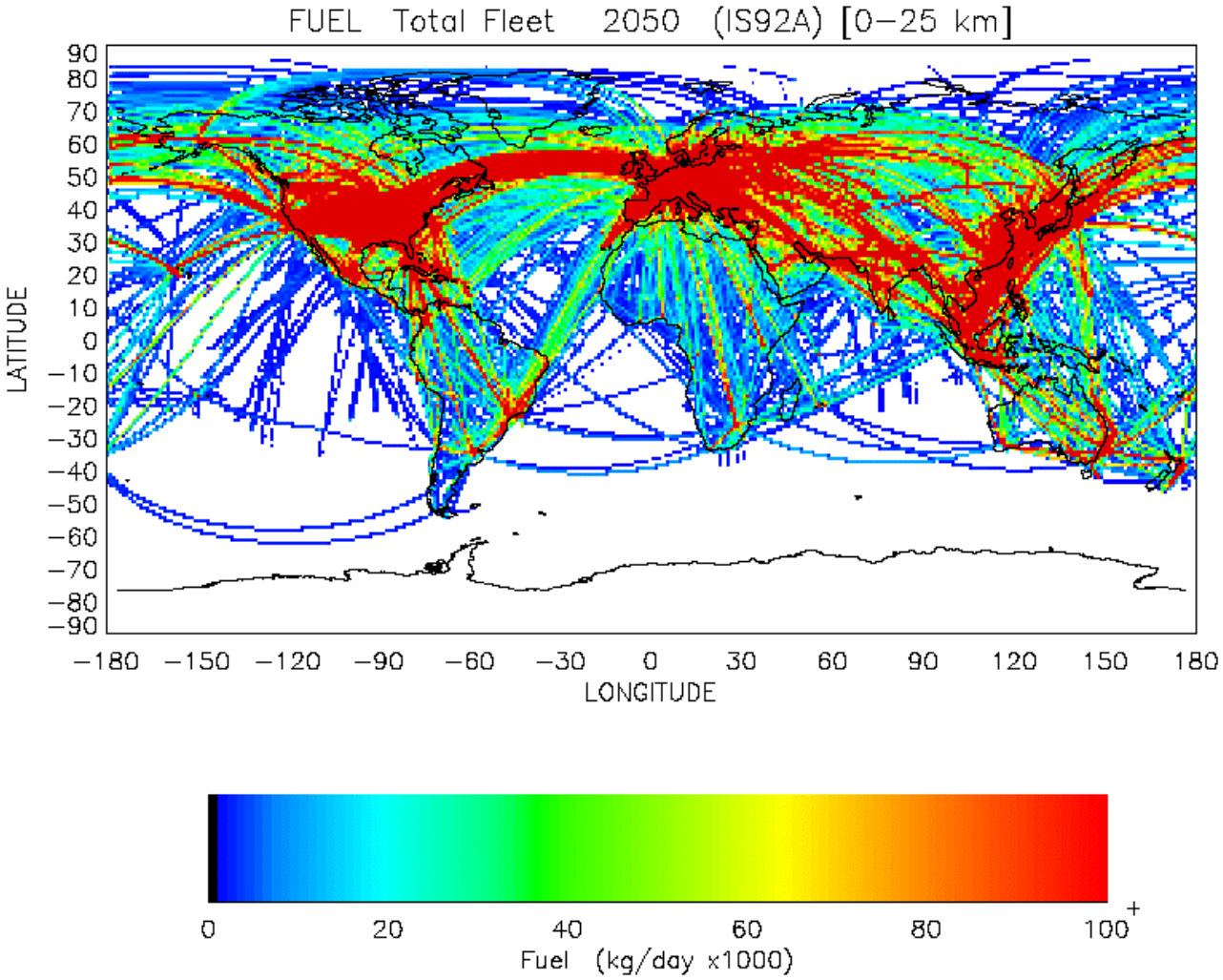
- 5 aircraft size classes with 4 technology levels
- Current fleet modeled by estimated 1997 averages for each class, modified with time to reflect retirement of older aircraft
- Generic airframe/engine models used for 1997, AST, and AST+Base technology levels
- FESG projections for military and GA used directly





Potential Impact of Technology Advances

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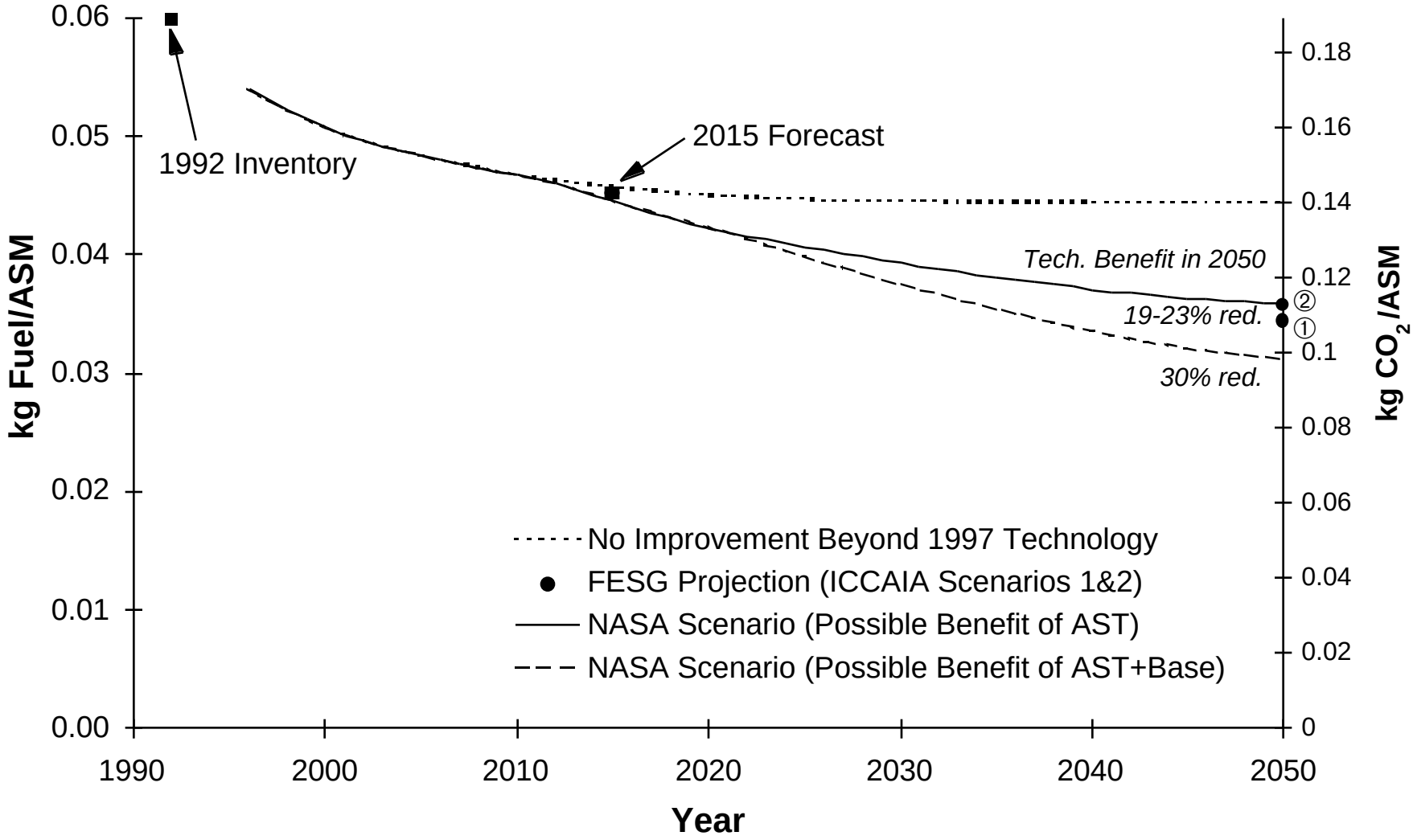
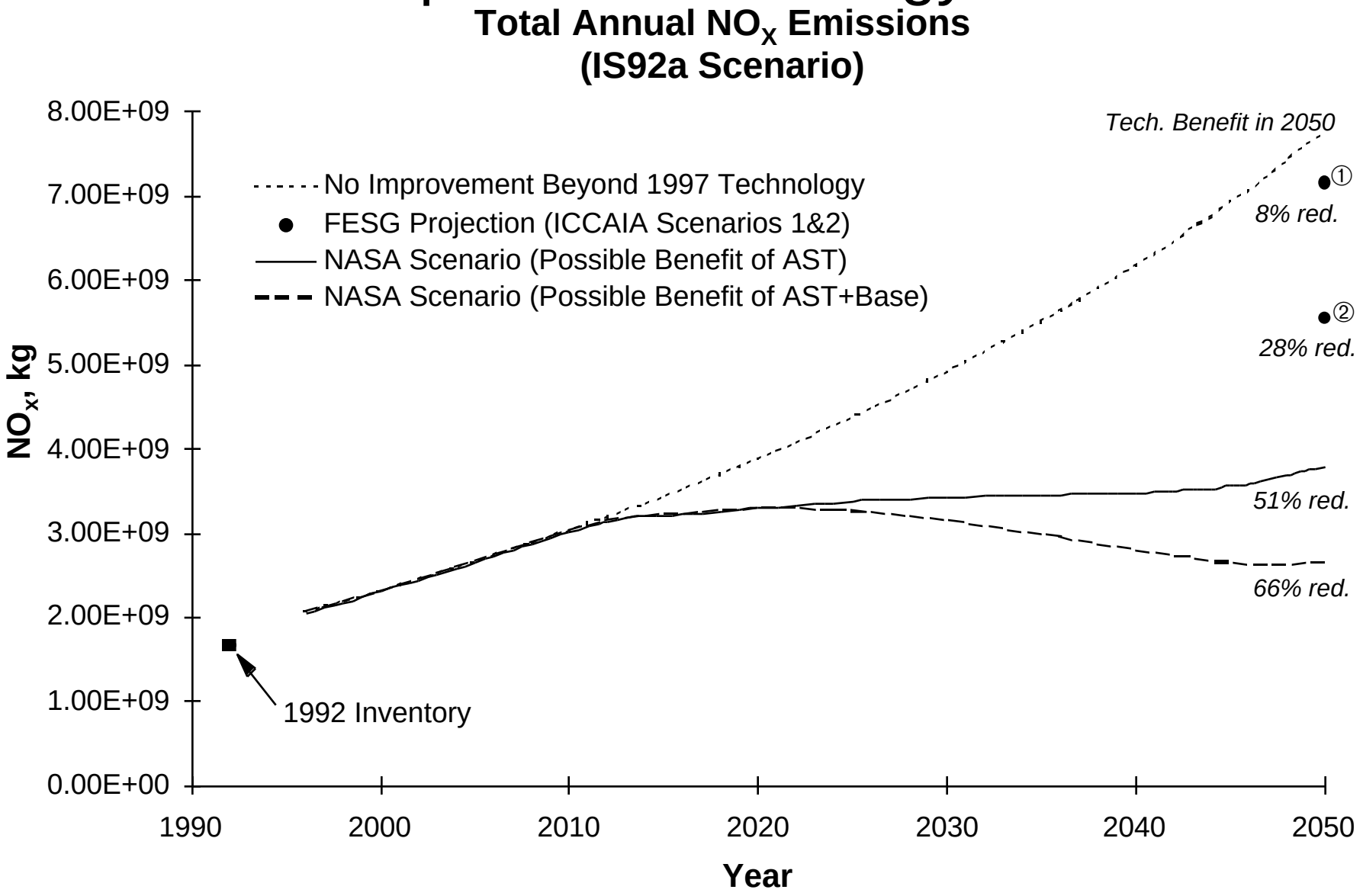
−30
−40
−50
−60
−70
−80
−90
−180 −150 −120 −90 −60 −30 0 30 60 90 120 150 180
LONGITUDE
0 20 40 60 80 100+
Fuel (kg/day x1000)

Potential Impact of Technology Advances

Fleet Average Fuel Consumption (Commercial Transport)
(IS92a Scenario)

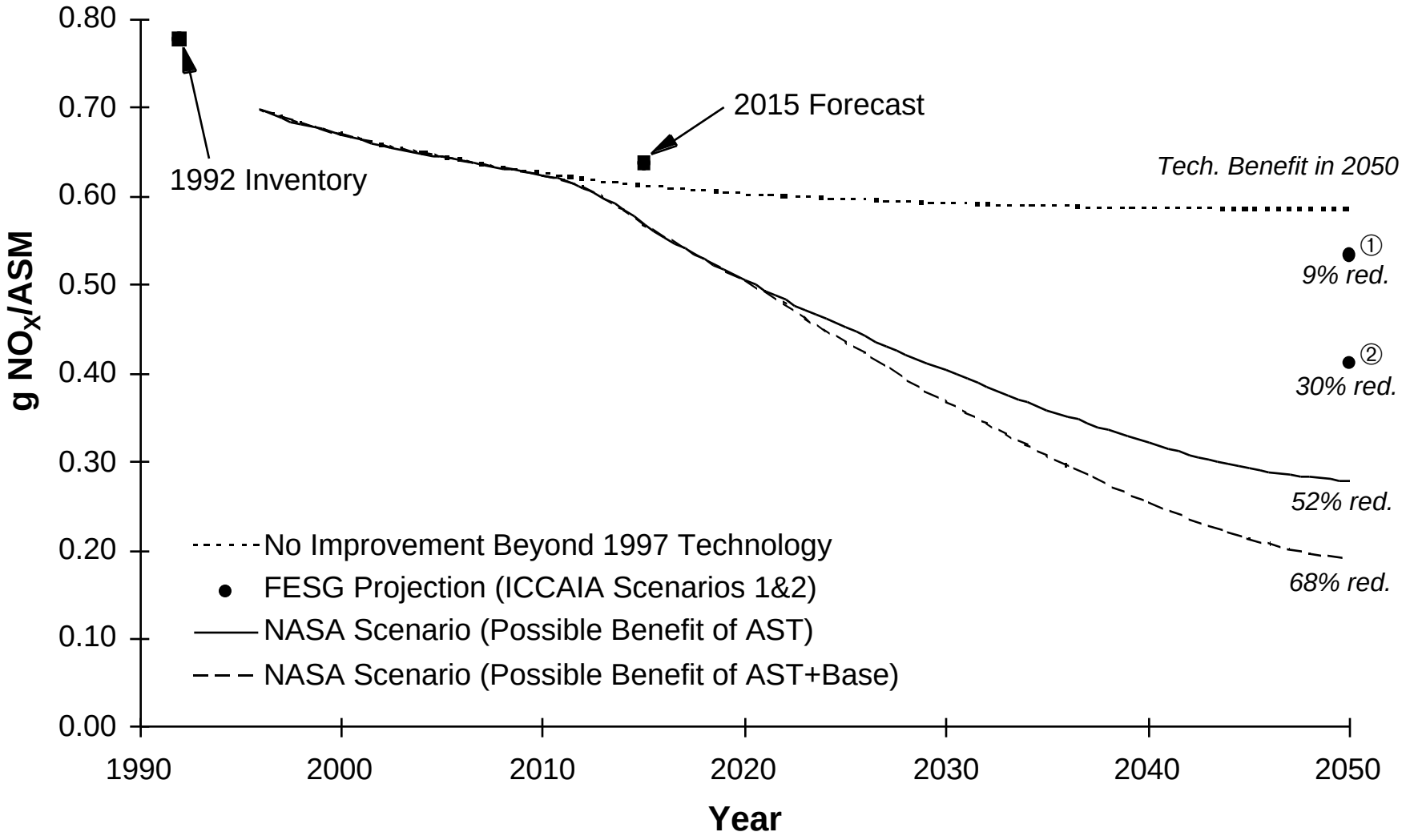


Potential Impact of Technology Advances



Potential Impact of Technology Advances

Fleet Average NO_X Emission Factor (Commercial Transports)
(IS92a Scenario)



Summary and Conclusions

- Projected advances in technology are not sufficient to counteract growth in traffic demand (IS92a scenario) for either ICCAIA or NASA technology scenarios
  - Fuel burn projected to increase 150-190% by 2050 relative to today
  - NO_X emissions projected to increase 30-250% by 2050 relative to today
- NASA technology scenarios indicate a possible 0-13% reduction in fuel burn and 30-60% reduction in NO_X emissions in 2050 relative to ICCAIA scenarios
- Impacts of technology advances on future total emissions are a function of the opportunity for introduction of new aircraft into the fleet
- For the NASA technologies to be viable they must be compatible with the other NASA “3 Pillar” goals, including the affordability of air travel goal